

## Forces and Equilibrium Worksheet

1.

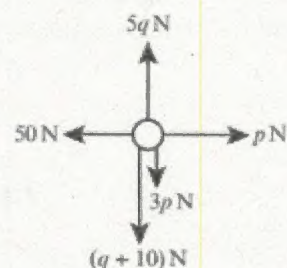
A trapeze bar is suspended motionless from the ceiling by two ropes. Draw a force diagram to show the forces acting on the ropes and the trapeze bar.

2.

A car's engine applies a force parallel to the surface of a horizontal road that causes the car to move with constant velocity. Considering the resistance to motion, draw a diagram to show the forces acting on the car.

3.

The diagram shows a particle acted on by a set of forces. Given that the particle is at rest, find the value of  $p$  and the value of  $q$ .

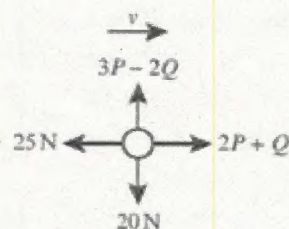


4.

Given that the particle in this diagram is moving with constant velocity,  $v$ , find the values of  $P$  and  $Q$ .

### Problem-solving

Set up two simultaneous equations.



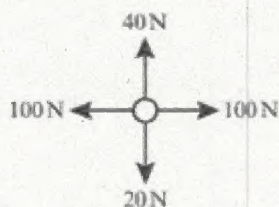
5.

Each diagram shows the forces acting on a particle.

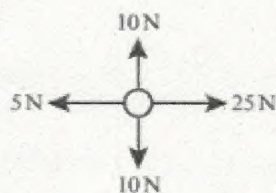
i Work out the size and direction of the resultant force.

ii Describe the motion of the particle.

a



b





6.

A truck is moving along a horizontal level road. The truck's engine provides a forward thrust of 10 000 N. The total resistance is modelled as a constant force of magnitude 1600 N.

- a Modelling the truck as a particle, draw a force diagram to show the forces acting on the truck.
- b Calculate the resultant force acting on the truck.

7.

A car is moving along a horizontal level road. The car's engine provides a constant driving force. The motion of the car is opposed by a constant resistance.

- a Modelling the car as a particle, draw a force diagram to show the forces acting on the car.
- b Given that the resultant force acting on the car is 4200 N in the direction of motion, and that the magnitude of the driving force is eight times the magnitude of the resistance force, calculate the magnitude of the resistance.

**Problem-solving**

8.

The forces  $\begin{pmatrix} a \\ 2b \end{pmatrix}$  N,  $\begin{pmatrix} -2a \\ -b \end{pmatrix}$  N and  $\begin{pmatrix} 3 \\ -4 \end{pmatrix}$  N act on an object which is in equilibrium.

Find the values of  $a$  and  $b$ .

9.

In this question,  $\mathbf{i}$  represents the unit vector due east, and  $\mathbf{j}$  represents the unit vector due north. A particle is acted upon by forces of:

- a  $(-2\mathbf{i} + \mathbf{j})$  N,  $(5\mathbf{i} + 2\mathbf{j})$  N and  $(-\mathbf{i} - 4\mathbf{j})$  N
- b  $(-2\mathbf{i} + \mathbf{j})$  N,  $(2\mathbf{i} - 3\mathbf{j})$  N and  $(3\mathbf{i} + 6\mathbf{j})$  N

Work out:

- i the resultant vector
- ii the magnitude of the resultant vector
- iii the bearing of the resultant vector.

10.

The forces  $(2a\mathbf{i} + 2b\mathbf{j})$  N,  $(-5b\mathbf{i} + 3a\mathbf{j})$  N and  $(-11\mathbf{i} - 7\mathbf{j})$  N act on an object which is in equilibrium. Find the values of  $a$  and  $b$ .

11.

Three forces  $\mathbf{F}_1$ ,  $\mathbf{F}_2$  and  $\mathbf{F}_3$  acting on a particle  $P$  are given by the vectors  $\mathbf{F}_1 = \begin{pmatrix} -7 \\ -4 \end{pmatrix}$  N,  $\mathbf{F}_2 = \begin{pmatrix} 4 \\ 2 \end{pmatrix}$  N and  $\mathbf{F}_3 = \begin{pmatrix} a \\ b \end{pmatrix}$  N, where  $a$  and  $b$  are constants.

Given that  $P$  is in equilibrium,

- a find the value of  $a$  and the value of  $b$ . (3 marks)
- b The force  $\mathbf{F}_1$  is now removed. The resultant of  $\mathbf{F}_2$  and  $\mathbf{F}_3$  is  $\mathbf{R}$ . Find:
  - i the magnitude of  $\mathbf{R}$  (2 marks)
  - ii the angle, to the nearest degree, that the direction of  $\mathbf{R}$  makes with the horizontal. (3 marks)